Stated Meeting, February 18th, 1845.

VICE PRESIDENT WETHERILL in the Chair.

A paper by Mr. Cassin, intended for publication, entitled "Descriptions of two Raptorial Birds, presumed to be new, in the collection of the Academy of Natural Sciences," was read and referred to the following Committee—Mr. S. F. Baird, Mr. Phillips, and Dr. T. McEuen.

Dr. Morton offered the following resolution, which he stated was the result of a communication with Prof. Rogers in reference to the subject in question:

Resolved, That a Committee of three members be appointed to confer with Prof. Rogers, in relation to the Collection of Rocks, Minerals and Fossils, made by him during his recent Geological Survey of the State of Pennsylvania, and to report on the possibility of having said collection deposited in the Museum of the Academy.

The resolution was adopted, and the Committee appointed to consist of Dr. Morton, Mr. Wetherill, and Mr. Ashmead.

Meeting for Business, February 25th, 1845.

VICE PRESIDENT MORTON in the Chair.

The Librarian exhibited the several stamps, which the Library Committee had been authorised to procure by a late resolution of the Society. The design having been approved, the Librarian and the members of the Library Committee were directed each to be provided with a stamp, and to place the impressions as soon as practicable on all the books now in the possession of the Society, or which may be hereafter received.

The Committee to whom was referred a communication by Prof. Johnson, read at the meeting of the 11th inst., reported in favour of publication.

Prof. Johnson first states some of the methods which have been hitherto employed by Chemists and others, to ascertain the relative heating powers of fuel.

1. *The heating of water*, without converting it into vapour, as practised first by Rumford, and more recently by other experimenters, particularly by Despretz and Dulong. The French chemists assume as the *unit of calorific power*, 1 gram of water heated 1° centigrade, (1.°8 Fahr.) The number of such units produced by burning 1 gram of combustible is termed its *colorific efficiency*.

2. *The melting of ice*, as in the calorimeter of Lavoisier and Laplace, also employed by Hassenfratz. The heat of fluidity, (135° Fahr.) is here the measure of effect.

3. *The heating of air*, or maintaining a certain difference between an interior room in which combustion is conducted, and an exterior one, kept cool by the open air. The *length of time* such difference is maintained by a given weight of each fuel, is the measure of its efficiency. This is the method of Mr. Marcus Bull.

4. *Combustion in contact with metallic oxides*,—measuring the heating power by the weight of metal, reduced on the supposition that the latter is proportionate to the weight of oxygen withdrawn. This is illustrated by M. Berthier's process by litharge.

5. *The reduction of the nitrate or chlorate of potash to the state of a carbonate*, by fusing these salts, and then gradually adding the combustible, till complete saturation has taken place.

6. *The practice of the Cornish engineers*, of measuring the efficiency of fuel by the weight of water, which a given bulk of it (as 1 bushel) will raise one foot high, when burned under a boiler driving a pumping engine.

7. *The distillation of the coals to ascertain the weight of fixed carbon which they contain*, suggested by the experiments of Mr. Pfyfe, of Edinburgh; the weight of that constituent being supposed to measure the heating power.

8. *Ultimate analysis*; which assumes that the quantity of heat developed by an organic combustible, depends on the heating power of the carbon which it contains, added to that of its excess of hydrogen, above what is required to combine with its oxygen in forming water. This method has been applied by Messrs. Peterson and Schoedler to wood, and by Richardson, Regnault and others, to coals.

9. *The direct or practical trial by evaporation*, as practised by Messrs. Parkes, Wicksteed, Pfyfe, Schanfhautl and Manby in Great Britain, by Messrs. S. L. Dana, A. A. Hayes, J. A. Francis, and more recently by Prof. J. himself in this country. (The results of the trials last referred to are contained in the Report to the Navy Department on American coals recently published by Congress)

10. *The melting of iron* either in a reverberatory or a cupola furnace, the weight of metal fused by one part of combustible being the standard of comparison.

11. *The performance of smith's work of a uniform character*, such as the manufacturing of chains by means of the several varieties of fuel. The number of links of chain formed by a given weight of each coal, is here the measure of useful effect.

The object of the present communication is mainly to exhibit the relation between the results obtained by the *eighth*, and those by the *ninth* method of trial above mentioned.

The existence, in bituminous coals, of variable proportions of nearly pure charcoal, is referred to as furnishing evidence of a want of homogeneousness in this class of bodies. A diversity of results may consequently be expected when ultimate analysis is resorted to for the purpose of establishing a theory of transmutations, or of demonstrating what changes have occurred in bringing vegetable substances into the state of bituminous coal. Those who assume *woody fibre* as the sole basis from which it has been derived, do not pretend to prove that the other proximate constituents of vegetables, the resinous matter, for example, and the oily component of seeds, have been wholly removed. Hence analyses of coal applied to this purpose may not always lead to unobjectionable inferences. But as means of determining the calorific power of combustible bodies, they may, especially when performed on average samples, or multiple specimens, afford information both interesting to science and valuable to the arts.

The relation between the calorific power *calculated* from analysis, and the practical heating power decided by evaporating water, is determined for six different varieties of bituminous coals, varying considerably in their composition.

Drawings of the apparatus employed for both these purposes were exhibited, and their action explained. That used in evaporation is so constructed as to determine the proportion of heat expended on the products of combustion, as well as that employed to generate steam.

In applying calculations to the ultimate analyses of coals as well as to the products of combustion, the atomic weight of carbon is assumed to be six, of oxygen eight, and of nitrogen fourteen times that of hydrogen, in accordance with the recent determinations of Dumas. In calculating evaporative powers, the latent heat of steam is taken at 1030° Fahr., according to Prof. J.'s own investigations of that subject.

In ascertaining the relative efficiencies and values of combustible bodies, with a view to economical applications, it is necessary to take them either as found in nature, or as supplied to commerce, including, of course, whatever impurities they may chance to contain. But in order to deduce general relations between bodies differently constituted, in regard particularly to their combustible constituents, the comparison must be made after deducting the waste, or incombustible matter found in the crude state of the fuel. This principle is applied both to the ultimate analysis and to the evaporative experiments; and hence in the following table both *the calculated evaporative power of the carbon constituent*, (column 15,) and the *total evaporative efficiency by experiment*, (column 18,) are referred to, and calculated for, one part by weight of *combustible matter*.

The relation between the *fixed* and the *volatile* combustible matters of coals, is liable to considerable variation, according to the rate of distillation to which they are subjected. The more slowly this process is conducted, the higher (within

certain limits) will be the proportion of fixed carbon.* The estimation of heating powers, therefore, from the quantity of fixed carbon which coals contain, if not wholly erroneous in principle, must be liable to considerable uncertainty in practice.

Many highly bituminous coals contain more than 5 per cent. of materials convertible into ammoniacal liquor by simple distillation without contact of air. This is proved on the largest scale in the manufacture of illuminating gas. That proportion, therefore, is not only unavailable for heating purposes, but it also abstracts from the really combustible materials of the fuel, all the heat, sensible and latent, which the vaporized ammoniacal products receive during combustion.

The proper *water of combustion*, namely, that derived from the *hydrogen in excess*, and oxygen of the atmosphere, must in every instance where heat is applied to evaporate water above the boiling point, as in all ordinary steam boilers, be likewise incapable of giving up its latent, as well as much of its sensible heat.

The average specific gravity of the six varieties of bituminous coals assayed is 1.31,—that of water at 60° being unity. Admitting the hydrogen in its solid state to have a density of only 1.25, it must in passing into the state, first of gaseous hydrogen, and then into that of watery vapour, (still having the same bulk as the hydrogen,) undergo an enlargement to 2117 times its original bulk. This volume is farther increased according to the usual law of gaseous expansion, by whatever heat above boiling point is left in the vapour, when it passes away from the surface to be heated. In a well constructed evaporative apparatus producing steam of 6 pounds pressure, in which the circuit traversed by the gases after passing the grate, and before reaching the chimney, was 121 feet, the temperature was generally about 100° above the boiling point; and the watery vapour, being of course surcharged with heat, possessed 2431 times the bulk which it had in the solid state and at 60 degrees of temperature.

By the experiments of Dulong, (Comptes Rendus, tom. 7,†) one gram of pure carbon developes, in burning, heat enough to raise the temperature of 7170 grams of water, 1° centigrade, or 12906 grams 1° Fahrenheit. This latter number is, therefore, used as a co-efficient, by which to multiply the numbers in the 12th column of the following table to obtain those of the 15th. By the same authority, 1 gram of *gaseous* hydrogen gives heat sufficient to raise 62,535 grams of water 1° Fah.

The average *excess of hydrogen* for the six varieties of coal tried by evaporation, as deduced from columns 13 and 14 of the table, is 4.636 per cent. which, calculated after the manner of the European chemists, ought to possess an evaporative power of 2.814. This would raise the average of the 15th column from 10.700 to 13.514, as the calculated evaporative power of the unit of combustible matter, showing the calculated to be 26.3 per cent. higher than the experimental effect.

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* See Proceedings of the Acad. of Nat. Sciences, Vol. 2, pages 9—10.

† See also Peclet, Traité de la Chaleur, Tom. I, p. 50.

Table exhibiting the analyses of several varieties of Bituminous Coal, both into their proximate and their ultimate constituents, with the calculated and the experimental determination of their evaporative powers.

Designation of the coals.	Specific gravity.	Proximate Analysis. Composition of the raw coal in 100 parts. Moisture expelled below 250° F.	Sulphur.	Volatile combustible matter	Fixed Carbon.	Earthy matter.	Ratio of fixed to 1 of volatile combustible matter.	Ultimate analysis. Grains of Dried coal assayed.	Carbonic acid collected.	Water collected.	By calculation, the *combustible matter* in 100 parts is found to be constituted of Carbon.	Hydrogen.	Oxygen and Nitrogen.	Calculated evaporative power of the carbon alone in one of combustible matter, by Dulong's coefficient, from water at 212°.	Practical evaporative power. Pounds of water from 212° to one of combustible matter. Evaporated from the boiler.	Vaporizable by the heat expended on the gaseous products of combustion.	Total of evaporative efficiency of one part of combustible matter, by experiment on a practical scale.	Difference between the calculated and the experimental efficiency of the combustible matter.	Remarks.
Summit Portage rail road, Cambria Co. Pennsylvania.	1.3617	0.700	1.500	18.195	64.245	15.360	3.535	7.26	20.62	3.23	91.955	5.867	2.178	11.522	10.238	1.312	11.550	—.028	Ultimate analysis effected by burning in contact with scale oxide of copper.
Midlothian, "new shaft," Virginia.	1.3006	0.914	2.282	29.274	62.050	5.480	1.966	4.57	14.82	2.23	93.620	5.739	0.641	11.731	10.191	1.269	11.460	+.271	Analysis by scale oxide as above.
New Castle, England.	1.2567	1.461		28.312	68.377	1.850	2.415	6.46	19.56	3.21	84.157	5.626	10.218	10.545	9.178	1.720	10.898	—.353	Analysis by same material as above. The heat expended on gases is calculated from the mean result of several other coals of similar constitution.
Clover Hill, Virginia.	1.2887	1.277	0.514	28.409	65.425	4.375	2.268	6.05	17.68	2.58	83.393	4.958	11.649	10.445	8.588	1.949	10.537	—.082	
Scotch.	1.2759	1.365		35.586	60.342	2.707	1.696	7.64	22.60	3.75	82.952	5.607	11.441	10.393	8.866	1.338	10.206	+.187	It appears that, on an average, these coals expended in evaporating water from the boiler 85.35, and on the products of their combustion 14.65 per cent. of their whole heating power. Both the *sum* and the *number* of differences between the practical and the calculated evaporative powers, affected by the positive sign, are seen in the last column to be the same as those affected by the negative sign.
Caseyville, Kentucky, and Cannelton, Indiana.	1.3920	1.150		30.669	44.493	23.687	1.450	4.21	8.96	1.92	76.335	6.663	17.002	9.565	7.734	1.823	9.557	+.008	
Averages.	. .	. .	. .	. . .	. . .	. . .	. .	. .	. .	. .	. . .	. .	. . .	10.700	9.133	1.5685	10.701	. . .	
Osage River, Missouri.	1.2000	1.670	0.482	41.348	51.160	5.340	1.237	6.94	19.95	3.69	81.855	6.168	11.977	10.256					No evaporative trials of Osage coal, or of bitumen, have been made.
Pure bitumen.	1.1558	.000		72.438	24.799	2.761	0.342	8.16	22.60	5.78	77.679	8.023	14.298	9.464					

The data furnished by the preceding table afford the means of ascertaining the proportion of its carbon volatilized in the distillation of the *combustible matter* in each kind of coal.

The calculations prove that of its whole carbon-constituent, the per centage volatilized, was as follows.

Cambria county coal, ...	16.767
Midlothian, new shaft, ...	29.195
New Castle, ...	15.967
Clover Hill, ...	16.847
Scotch Cannel, ...	24.169
Caseyville, Ky., Cannel, ...	22.452
And that the average was	20.883

The *identity* of results obtained in the averages of the 15th and 18th columns should seem to demonstrate that the heating power of bituminous coals is proportionate to the *carbon* which they severally contain.

The Monthly Report of the Corresponding Secretary was read and adopted.

John L. Le Conte, M. D., of New York, and M. Clot Bey, M. D., Surgeon in Chief to the Viceroy of Egypt, were elected Correspondents of the Academy.